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Comovements among European equity sectors: Selected evidence from the consumer discretionary, consumer staples, financial, industrial and materials sectors

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Abstract

This paper examines comovements between equity sectors across European markets during the post-euro adoption period 1999-2002. The markets comprise six selected Member States of the European Union (EU): namely, Belgium, Finland, France, Germany, Ireland and Italy. The five sectors selected are classified according to the Global Industry Classification Standard (GICS). They include the consumer discretionary, consumer staples, financial, industrials and materials sectors. Multivariate cointegration procedures, Granger-causality tests and generalised variance decomposition analyses based on error-correction and vector autoregressive models are conducted to examine long and short-run relationships among these markets. The results indicate that there are few stationary long-run relationships between sectors in different markets, but many significant short-run causal linkages between these sectors. Variance decomposition indicates that the consumer discretionary, financial and materials sectors in the EU are relatively more integrated than the consumer staples and industrials sectors. However, irrespective of the sector examined the large equity markets of France, Germany and Italy remain the most influential in terms of causality and the proportion of variance accounted for by innovations in these same markets.

Keywords: Financial integration, sectors and industries, portfolio diversification, market efficiency.
JEL classification: C32, F36, G15.

1. Introduction

In recent years, the degree of comovement or integration of prices among world equity markets has increased dramatically, and concomitantly a voluminous empirical literature concerned with analysing these interrelationships has arisen. Justification for this interest is not hard to find. Although the gradual lifting of restrictions on capital movements, relaxation of exchange controls and improved accessibility to information have led to a substantial increase in international stock market activities and the flow of global capital, they have also increased the vulnerability of individual markets to global shocks. Substantial integration then calls for greater cooperation between prudential and monetary regulators in different markets to handle these shocks, particularly in groups sharing a common currency or with substantial trade and investment links. Moreover, if equity markets are fully integrated, then the benefits of international diversification are reduced. If as hypothesised, high correlations of returns exist between markets, diversification may not allow investors to reduce portfolio risk while holding expected return constant [for early work in this area see Levy and Sarnat (1970) and Solnik (1974)].

These similarities in stock price fluctuations exist for four main reasons. To start with, comovements may arise where economies as a whole are more integrated, such as within the

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European Union and especially given the introduction of the single currency. In this case, substantial trade and investment linkages, common institutional and regulatory structures and shared macroeconomic conditions imply equity pricing more closely reflects regional, rather than national, factors. A second source of commonality may arise from country-specific shocks that are rapidly transmitted to other markets. This transmission can occur through the international capital market provoking a reaction in domestic capital markets (known as market contagion). This hypothesis also suggests that markets that are larger in size and are more dominant are likely to exert a greater influence on smaller markets. The third source of commonality arises from shocks specific to sectors of each economy. For example, if a technology shock affects a particular sector, stock price comovements may arise from connections between this and other sectors within a market. Lastly, a final source of commonality is from shared investor groups. For example, when two countries are geographically proximate and have similar groups of investors in their markets, these markets are also likely to influence each other.

In fact, equity markets within the European Union represent a pertinent context within which to examine such comovements. Not only do these geographically close and globally important markets have extensive trade and investment linkages in the first instance, the institutional, regulatory and macroeconomic harmonisation brought about by the common market and currency implies a very strongly integrated regional market. Moreover, European equity markets have increasingly attracted non-European investors to the potential benefits of international diversification, and the eastwards expansion of the EU in the next several years will only increase its share of global capitalisation. However, it has also been persuasively argued [see, for example, Akdogan (1995), Meric and Meric (1997), Friedman and Shachmurove (1997) and Cheung and Lai (1999)] that comparatively recent developments in the EU to deepen both political and economic integration have diminished the prospects for diversification. In fact, Akdogan (1995: 111) suggests that "in light of recent developments towards greater financial integration within the Union, one might argue that European equities are priced in an integrated market and not according to the domestic systematic risk content".

Unfortunately, "although a number of articles dealing with the co-movements of the world's equity markets are available, articles focusing solely on European equity markets are virtually non-existent" (Meric and Meric 1997). Furthermore, even when European equity markets are examined in a broader multilateral context (that is, in conjunction with North American and Asian capital markets), an emphasis is usually placed upon the larger economies. For example, Darbar and Deb (1997) included only the U.K. in their study of international capital market integration, Kwan *et al*. (1995), Francis and Leachman (1998) and Masih and Masih (1999) added Germany, Arshanapalli and Doukas (1993) excluded Germany and focused on France and the U.K., Cheung and Lai (1999) removed the U.K. and added Italy to France and Germany, and Solnik *et al*. (1996) and Longin and Solnik (1995) included Germany, France, Switzerland and the U.K. This bias is equally noticeable in studies that concentrate on European equity markets, including Espitia and Santamaria (1994), Abbott and Chow (1993), Shawky *et al*. (1997), Ramchand and Susmel (1998), Richards (1995) and Chelley-Steeley and Steeley (1999) where only the larger European economies were included.

A more startling omission in the literature is that despite the widespread use of cointegration to examine comovements among national markets, little use of these techniques has been made to examine comovements between sectors in different national markets [see, for example, Baca et al. (2000)]. This is important in a global context as the extent to which sectors in different markets comove is likely to be related to the differing nature of these sectors, the extent of multilateral and bilateral trade liberalisation, and capital flows and control. These are likely to vary across sectors, such that some sectors in a market may be more or less related to sectors in another, than suggested by the market itself. Such differences are likely to be especially important in the European Union where the substantive liberalisation of the flows of goods and services, capital and labour owes much to regional policy and regulation.

Accordingly, the purpose of the present paper is to examine equity comovements between selected sectors in several different markets within the European Union's regional market. The paper itself is divided into four main areas. The second section briefly surveys the empirical literature concerning international, regional and sectorial equity comovements and pricing in the European context. The third section explains the methodology and data employed in the present analysis. The results are dealt with in the fourth section. The paper ends with some brief concluding remarks.

2. European equity comovements by market and sector

At least four phases of European structural and institutional change *vis-à-vis* financial integration have been identified. To start with, in the early 1960s the idea of financial integration within the European Union [then European Community (EC)] was firmly established. Consisting of six Member States at the time, the Council of Ministers adopted two directives setting out initial obligations for the removal of capital controls. These directives to deregulate capital transactions were closely associated with a number of basic financial freedoms proposed for the nascent Community, including short-term and medium-term credit, personal capital movements, and investments and trading in quoted securities.

In sharp contrast to the 1970s, marked as it was by the collapse of Bretton Woods and the OPEC oil crises, the early 1980s held more promise as the second phase of European financial integration. In the early and mid-1970s economic pressures were relieved, and the establishment of the European Monetary System (EMS) saw many EC economies participating in the central apparatus of the EMS, namely the exchange rate mechanism (ERM), pursue a number of policies that brought about convergence in cost and commodity prices. At the same time, several Member States (led by Germany and the U.K.) independently removed all restrictions in capital markets in their domestic markets thereby accelerating the movement towards financial unity.

The third phase in financial integration is associated with the European Commission's initiation of a new 'European approach' to financial integration detailed in a 1983 communication and the so-called 1985 White Paper (Akdogan 1995). Together, these directives involved four areas of action towards full financial integration: (i) the removal of restrictions on capital movements and on the provision of financial services across national borders; (ii) a series of regulations to ensure the stable and efficient functioning of capital markets; (iii) tax harmonisation measures to remove fiscal distortions; and (iv) guidelines on the lending/borrowing activity of EC institutions.

The final phase in the process of European financial integration covers the period between when the parts of the 1992 Maastricht Treaty dealing with economic and monetary union were being negotiated and the move into the third and final stage of EMU. Along with a number of institutional changes, in order to qualify for the final stage of EMU Member States were obliged to attain a high degree of sustainable economic convergence. Progress towards this objective was measured against a range of criteria, including inflation, government deficits and debt, exchange rate stability and long-term interest rates. Notwithstanding the obvious focus of economic convergence on the integration of European currency markets, the reaction of capital markets to developments in the European monetary sector has gone far towards quickening the pace of overall financial integration.

The economic integration of the EU at the national level has manifested itself at the sectorial level in two major ways. First, the creation of the customs union has obviously created trade diversion from third parties and strengthened trade among the Member States. However, one particular feature is that intra-industry trade has increased strongly. That is, despite the presumption that a customs union would promote specialization by country, different countries within the EU have tended to specialize in different segments of highly interrelated sectors. For example, the car industry in the EU is spread across a large number of countries, each specializing in a sub-sector of a highly interrelated product market. Likewise, financial services have experienced substantial cross-border growth within the EU as communication has improved and regulation eased, while non-tariffs barriers in the form of regulation has hindered growth outside the EU (Hansen 2001: 126).

Second, there has been a dramatic increase in foreign direct investment (FDI) among member states within the EU. Much of this growth can be attributed to the creation of the internal market program, the deregulation of financial markets and technological innovations (Molle 2001: 189). For example, FDI in the form of cross-border mergers and acquisitions (M&A) in the manufacturing industry tripled from 1986 to 1989 (Hansen 2001: 149). The importance of FDI is even more pronounced in the service sector with more than seventy-five percent of intra-EU FDI inflows being service-related. Market liberalisation and privatisation of the energy and telecommunications sectors across the EU have been a major factor in this regard (Molle 2001). Combined together, the growth in intra-industry trade and investment implies that the degree of financial integration among sectors within the EU, especially in services, and to a lesser extent manufacturing, may be even greater than that suggested at the national level.

Nevertheless, it is recognized that there are still two major impediments to full financial integration in the EU, both of which are likely to be particularly pronounced at the sectorial level. First, there has been a growing political debate in the EU about taxation with the belief that harmonisation is a logical progression from creating a single market with a single currency and integrated capital markets. However, the progress towards tax harmonisation has been slow. An explanation for this can be partly attributed to the Single Market Program. Although the Single Market Program has increased cross-border trade and investment within and into the EU, it has also added the incentive for countries to make their business tax regimes as competitive as possible (Flowers and Lees 2002: 57). For example, Ireland’s special 10 percent tax regime for manufacturers [when compared to 56 percent for most corporate activities in Germany] is relatively attractive to foreign investors, especially from the United States.

Moreover, not only companies are affected by the differential tax system, individual investors are also subject to complicated fiscal regimes that differ greatly from one country to another (Gross and Lannoo, 2000: 103). For example, German residents can receive a tax credit from corporate income tax. However, this tax is not available to non-residents, but non-residents can, depending on the existence of a bilateral tax treaty, benefit from a lower withholding tax rate. Similarly, in Italy a dividend tax credit of 56.25 percent applies to residents and local firms. This credit is currently only extended to France and the UK and no other EU Member States (Gross and Lannoo, 2000: 103). A recent attempt at the harmonisation of tax systems was made in 1997 including a code of conduct for business taxation aimed at eliminating preferential tax regimes, measures to eliminate distortions in the taxation of capital income, and plans to eliminate withholding taxes on cross border interest and royalty payments between countries being proposed.

Second, there are persistent differences in accounting practices within the EU. One part of this problem is conceptual, such that in the UK (and to a lesser extent the Netherlands) company accounts are expected to convey information of adequate standards and practices developed by the professions, whereas in continental Europe it is based on compliance with strict statutory requirements with a strong influence exerted by the tax authorities. Another major issue is that companies have to provide dual or multiple accounts when seeking funds outside domestic financial markets. This adds significantly to administration costs, and more importantly, makes it more difficult to compare financial reports and assess performance and investment strategies. In response to these issues, the European Commission recently proposed that the International Accounting Standards (IAS) be adopted for all European companies by 2005, though this likely to be complicated by the pace of acceptance in the UK and the US (Dzinkowski, 2001: 28).

It is within this evolving institutional setting that the empirical work on European financial (equity) integration has been framed. In one of the earlier studies, Espitia and Santamaria (1994) examined the prospects for international diversification among the capital markets of the EC. Using daily returns for the period October 1987 to September 1992 on the Madrid, Milan, Frankfurt, Paris and London stock markets, and specifying their analysis in both local currency and Swiss Francs, Espitia and Santamaria (1994) employed a vector auto-regressive (VAR) analysis to detect significant interrelations among markets, as well as identifying the information transmission mechanism. While the results indicated that a high level of correlation existed between daily equity returns in all markets, only London and Paris appeared to have any significant influence over the remaining markets. Moreover, the overall level of influence fell when returns were expressed in a common currency. Using this evidence Espitia and Santamaria (1994: 10) concluded: “the growing internationalisation of economic activity has brought about a reduction of ‘domestic’ factors which have an effect at the national level. This has caused the parallel effect of a greater correlation among markets…on the whole what is suggested is that international diversification does not have an excessive economic rationality”.

Employing an expanded sample of European equity markets [namely, U.K., Germany, France, Netherlands, Belgium, Denmark, Italy and Spain] Akdogan (1995) also used national share market indices to analyse financial integration, though defined in terms of monthly returns over the period 1978 to 1986. Akdogan (1995: 123) also included three regime switches:

> One is 1983, when the new approach to financial integration was initiated; another is the year 1985, when the White Paper was introduced. A final one is 1987, when the White Paper was implemented as the ‘Single European Act’…it seems reasonable that the pricing of European Community securities will become more international as opposed to domestic as we move from 1983 to 1985, from 1985 to 1987, and finally from 1987 onwards.

Employing a single-index EU capital asset pricing model (CAPM), Akdogan (1995) found that each market's proportion of systematic risk as explained by the integrated model had increased over the sample period, and thereby concluded that all European equity markets appeared to be integrated.

In contrast to the work of Akdogan (1995), more recent analyses of European financial integration have applied cointegration techniques. For example, Gallagher (1995) used weekly index data from the Irish, U.K. and German markets in conjunction with cointegration and Granger causality tests to examine short and long-run relationships before, during and after the 1987 stock market crash. However, the hypothesis of a greater degree of economic and financial integration was not supported, seemingly in contradiction to the fact that the "stock exchanges are connected by a common system of standards and regulation" (Gallagher 1995: 144). Nonetheless, the analysis also indicated "…there has been a significant increase in the correlation of short-run stock market returns as a result of a greater financial and economic integration with Germany [though] the increase is not sufficient to accept the hypothesis of no gains for Irish investors diversifying in to either the U.K. or German stock markets".

Malliaris and Urrutia (1996) also employed an error correcting model (ECM) to examine long-term links and short-term causality in European equity markets (U.K., France, Italy, Germany and Belgium). Observing a two way long-term relationship between each pair of European equity indexes, Malliaris and Urrutia (1996: 28) reasoned that "the significant long-term linkages reported in this paper…probably reflect the strong economic similarities that prevailed in these countries under our sample period and also their coordinated macroeconomic policies under a stable Exchange Rate Mechanism".

Evidence concerning European financial integration has been more mixed when samples have included smaller economies. For example, Friedman and Shachmurove (1997: 274) found that while "the large stock markets of the EC (Britain, France, Germany and the Netherlands) are found to be highly related, the smaller EC markets [Belgium, Denmark and Spain] are more independent". This finding was used to suggest that investors could achieve larger gains from international portfolio diversification by including smaller markets in their opportunity set (Friedman and Shachmurove 1997). Likewise, while Cheung and Lai (1999) found long-term comovements in French, German and Italian stock market indices, the results indicated no significant evidence of cointegration when Belgium and the Netherlands were included. The Cheung and Lai (1999) study is particularly interesting in that the long-term comovements in equity returns were linked with similar comovements in macroeconomic variables, including money supply and industrial production.

Lastly, Meric and Meric (1997) studied the comovements of the twelve largest European equity markets following the 1987 stock market crash. In common with earlier work by Gallagher (1995), Meric and Meric (1999) found that long-term comovements in equity prices increased, and hence international diversification benefits decreased, after this period. However, the average correlation coefficients of the minor European markets (including Norway, Denmark, Sweden and Austria) were generally smaller than the correlation coefficients of the larger economies.

The existing literature regarding the degree of European financial integration and the concomitant potential for international portfolio diversification may be summarised as follows. First, most empirical studies to date have indicated that the major equity markets (i.e.

Germany, United Kingdom, France and Switzerland) are closely integrated, thereby diminishing the potential for European portfolio diversification. This holds for both studies with a European focus and those examined in a broader international context [see, for example, Kwan *et al*. (1995), Richards (1995), Leachman and Francis (1995) and Hanna *et al*. (1999)]. However, evidence concerning financial integration in some of the smaller European equity markets (ie. Belgium, Netherlands, Ireland, Austria, Norway, etc.) is more mixed.

Second, evidence also exists that the level of financial integration is closely related to progress in EU economic convergence. That is, efforts to increase European monetary integration have been paralleled by adjustments in European financial integration. Akdogan (1995: 134) reasons that this makes EU capital markets an excellent sample to test financial integration, even before the adoption of the single currency:

> First, capital controls have been eliminated over EU exchanges. Second, exchange rates across the member states can float only within small margins. Third, indirect barriers, such as language difficulties, can be more easily assumed away for the EU investors who trade in EU markets than for other international investors who trade in other parts of the world. Finally, while much evidence exists concerning financial integration in major European equity markets, much less is known about financial integration across the full membership of the EU nor participants in the single currency area.

In contrast to the work on comovements between European national equity markets, which has placed an emphasis on cointegration techniques, empirical studies on the comovements between European equity sectors have generally relied upon simple correlation or factor models. For example, Grinold *et al*. (1989) decomposed portfolio stock returns from several countries into components representing factors. The results indicated that local market factors were dominant in most economies, though industries and global common factors also were found to be significant. On this basis, Grinold *et al*. (1989) concluded that the global importance of industries appeared to be increasing, and that some industries, such as oil and banking, appeared to be more global than others. Becker *et al*. (1992) used a similar approach and found that Switzerland, the Netherlands and the UK were most affected by this ‘international industry effect’ largely due to the dominance of the oil industry in the UK and the Netherlands, and the banking sector, pharmaceuticals and insurance industry in Switzerland. Conversely, Ireland, Spain and Italy were less affected by these global factors.

Drummen and Zimmerman (1992) also examined the structure of European stock returns using a multifactor model to extract common factors including currency, world, European, country and industry. Drummen and Zimmerman (1992) found that country factors (i.e. country market indexes) explained the major portion of stock price variation, and international factors (World, Europe) were relatively unimportant for Italian, Spanish and Scandinavian stocks which were generally smaller and less integrated. By contrast, the European stock market factor had some relevance for German, Dutch and Swiss stocks (where it explained more than 10 percent of variance) and for automobile and chemical stocks (where it explained 12 percent or more of variance). Overall, Drummen and Zimmerman (1992) concluded that correlations between stocks of the same industrial sectors are much less pronounced than the correlation between stocks within countries. On this basis, they suggested that the gains from diversifying across (but not within) industries are less substantial than the gains from diversifying across national stock markets, with the exception of the automobile, chemical, insurance, electronics, and oil and gas industry factors.

Becker *et al*. (1996) also examined the explanatory power of national and global industry factors regarding comovements in European equity markets. Using a simple factor model they found that global factors and national factors are of roughly equal importance in explaining the comovement of stock returns. Heston and Rouwenhorst (1994) likewise examined the influence of industrial structure on the cross-sectional volatility and correlation of country index returns for twelve European countries and seven sectors. By separating country and industry effects, they found that country indices (same country, different industries) are generally more volatile and less intercorrelated than industry indices (same industry, different country). Heston and Rouwenhorst (1994) concluded that since country effects are larger than industry effects, country diversification is a more effective tool for achieving risk reduction than industry diversification. In a later study, and on the basis of similar results, Heston and Rouwenhorst (1999) concluded that the country effect was on average larger than industry effect and that "…despite the convergence of economic policies and interest rates among EMU countries following the Maastricht treaty, no evidence exist that industry effects have become more important than country effects in European stock returns."

Griffin and Karolyi (1998) investigated whether industry effects explained more variation in industry indexes than country effects. Griffin and Karolyi (1998) concluded that non-traded goods industries (i.e. real estate, overseas trading, conglomerates, plantations and factory equipment) tend to be less integrated then traded goods (i.e., automobile, manufacturing, computers, electric utilities, office equipment and semi conductors). More recently, Heckman *et al*. (2001) undertook a study on the relative importance of countries and industries in determining European company returns for the period 1989 to 2000. At the country level, the variances of the country effects of the smaller, less liquid and less diversified markets, such as Austria and Norway, were found to be largest. On the other hand, the variance of the country effects of the larger, more diversified, multinational markets such as the Netherlands and the UK were found to be smaller. At the sector level, technology, energy, telecommunication services, utilities, and financial conglomerates were found to have the largest industry effects. Lastly, Arshanapalli *et al*. (1997) investigated the behaviour of nine industry groups in three regions including Europe. They found strong evidence of intra-industry volatility, but not similar across regions and consequently intra-industry diversification across regions appears to be an effective strategy for portfolio risk reduction because of the existence of industry specific sources of return variation rather than region-specific factors.

In summary, empirical studies on whether country factors dominate industry factors in determining stock price variation have been mixed. However, the overall evidence tends to suggest that sector-industries that have greater involvement in foreign trade (i.e., chemical, electrical, oil, gas, pharmaceutical etc.) tend to be more integrated than industries that mostly supply domestic goods (i.e., retail, utilities, real estates, etc.). Moreover, larger industrialised capital markets such as the US, the UK, the Netherlands and Germany tend to have larger industry effects, that is, more globally integrated industries.

3. Empirical methodology

The data employed in the study is composed of value-weighted equity sector indices for six selected European Union markets; namely, Belgium, Finland, France, Germany, Ireland and Italy. The selected markets are thought to be representative of diversity within the EU, encompassing both large and small markets. All data is obtained from Morgan Stanley Capital International (MSCI) and encompasses the period 1 January 1999 to 29 February 2002. MSCI indices are widely employed in the financial integration literature on the basis of the degree of comparability and avoidance of dual listing [see, for instance, Meric and Meric (1997), Yuhn (1997), Roca (1999) and Cheung and Lai (1991)]. Daily data is specified. It is generally argued that "daily return data is preferred to the lower frequency data such as weekly and monthly returns because longer horizon returns can obscure transient responses to innovations which may last for a few days only" (Elyasiani *et al*. 1998: 94).

The sector indices analysed are classified according to the Global Industry Classification Standard (GICS)[SM]. The GICS assigns each company to a sub-industry, and to a corresponding industry, industry group and sector, according to the definition of its principal business activity. Ten sectors, twenty-three industry groups, fifty-nine industries and one hundred and twenty-three sub-industries currently represent these four levels. The sectoral classifications are Consumer Discretionary, Consumer Staples, Energy, Financials, Healthcare, Industrials, Information Technology, Materials, Telecommunications, and Utilities, from which the following are selected:

I. Consumer Discretionary – encompassing those industries that tend to be most sensitive to economic cycles. The manufacturing segment includes automotive, household durable goods, textiles and apparel and leisure equipment. The services segment includes hotels, restaurants and other leisure facilities, media production and services and consumer retailing.
II. Consumer Staples – comprising companies whose businesses are less sensitive to economic cycles. It includes manufacturers and distributors of food, beverages and tobacco and producers of non-durable household goods and personal products, along with food and drug retailing companies.
III. Financial – containing companies involved in activities such as banking, consumer finance, investment banking and brokerage, asset management, insurance and investment and real estates.
IV. Industrial – including companies whose businesses are dominated by one of the following activities: the manufacture and distribution of capital goods, including aerospace and defence, construction, engineering and building products, electrical equipment and industrial machinery.
V. Materials – counting a wide range of commodity-related manufacturing industries. Included in this sector are companies that manufacture chemicals, construction materials, glass, paper, forest products and related packaging products, metals, minerals and mining companies, including producers of steels.

The paper investigates the integration among European equity sectors using vector autoregressive (VAR) modelling. The VAR model provides a multivariate framework where changes in a particular sector index are related to changes in its own lags and to changes in other sector indices. The model imposes few restrictions, if any, on the structural relationships between each sector analysed (Janakiramanan and Lamba, 1997). The model can be expressed as

$$Y_t = g + \sum_{k=1}^{p} A_k Y_{t-k} + e_t \tag{1}$$

where Y_t is an $n\times1$ column vector of daily returns on the sector index in time t, γ is a $n\times1$ column vector of constant terms, A_k is a $n\times n$ matrix of coefficients, e_t is a $n\times1$ column vector

of innovations such that $E(e_{it}) = 0$, $E(e^2_{it}) = s^2_i$, $E(e_{it}, e_{jt-k}) = 0$, and $E(e_{it}, e_{jt}) = s_{ij}$. The innovations, e_t, are then serially uncorrelated but can be contemporaneously correlated.
VAR requires that all variables are stationary and that the optimum number of lag lengths have been determined. To determine whether each series are stationary, the Augmented Dickey Fuller (ADF) unit root test is conducted. The test procedure is represented by the following expression

$$\Delta Y_t = a_0 + a_1 t + bY_{t-1} + \sum_{k=1}^{p} b\Delta Y_{t-1} + e \tag{2}$$

where Y_t denotes a series, ? $Y_t = Y_t - Y_{t-1}$, *ß* are the coefficients to be estimated, *p* is the number of lags necessary to ensure that the e_t is white noise, *t* is the trend term, a_1 is the estimated coefficient for the trend, a_0 is a constant, and e_t is white noise. The optimum number of lags to be used in the VAR model is determined by the likelihood ratio statistic (LR). The likelihood ratio statistic is

$$LR = (T - m)\{\log|\Sigma_0| - \log|\Sigma_A|\} \tag{3}$$

where *T* is the number of useable observation, *m* is the number of parameters estimated in each equation of the unrestricted system and $|\Sigma|$ denotes the determinant of the covariance matrix of the error term, and the subscript *0* and *A* denote the restricted and unrestricted VAR. The LR is asymptotically distributed $?^2$ with degrees of freedom equal to the number of restrictions. The test statistic given by equation (3) is used to test the null hypothesis of the number of lags being equal to *k - l* against the alternative hypothesis that the number of lags is *k = 2, 3…* and so on. The test procedure continues until the null hypothesis is accepted. The optimum lag corresponds to the lag when the null hypothesis is accepted.

The study uses cointegration techniques to examine the long run interaction between equity sectors and Granger [Granger (1969)] causality and variance decomposition tests to examine short run interactions. Cointegration is performed using the Johansen [Johansen (1991) and Johansen and Juselius (1990)] maximum likelihood procedure. This procedure has the advantage of providing estimates of all cointegrating vectors which exist among a set of time series and is based on the error correction representation of equation (1)

$$\Delta Y_t = g + \sum_{k=1}^{p-1} \Pi_k \Delta Y_{t-k} + \Pi Y_{t-p} + e_t \tag{4}$$

where $\Pi = -\left(I - \sum_{k=1}^{p} A_k\right)$ and $\Pi_i = -\left(I - \sum_{j=1}^{i} A_j\right)$. The likelihood-ratio test for the presence of at most *n - 1* cointegrating vectors is:

$$l_{trace}(r) = -T \sum_{k=r+1}^{n} \ln(l - \hat{l}_k) \tag{5}$$

where $\hat{l}_k$ is the estimated values of the characteristics roots obtained from the *?* matrix and *T* is the number of useable observations. The key feature of equation (5) is that the rank of the matrix *?* is equal to the number of independent cointegrating vectors. For example, if rank *(?) = 1*, then there is a single cointegrating vector and *?* Y_{t-p} is the error correction factor. For *1 < rank (?) < n*, the conclusion would be that there are multiple vectors. The test statistic, equation (5) tests the null hypothesis on the number of distinct cointegrating vectors being $r = 0$ versus $r > 0$, $r = 1$ versus $r > 1$ and so on. The critical values are found in Osterwald-Lenum (1992).

The Granger causality test determines if a lead-lag relationship exists between sectors and in what direction. That is, whether one market's sectors index helps forecast another's sector index. Equation (6) represents the traditional Granger regressions, when sector X is said to Granger cause (lead) sector Y, provided some coefficients b_k is not zero:

$$\Delta Y_t = g_0 + \sum_{k=1}^{n} b_k X_{t-k} + \sum_{j=1}^{n} c_j \Delta Y_{t-j} + u_t \tag{6}$$

Similarly, Y is causing X if some of b_k^* is not zero:

$$\Delta X_t = g_0^* + \sum_{k=1}^{n} b_k^* \Delta Y_{t-k} + \sum_{j=1}^{n} c_j^* \Delta X_{t-j} + u_t^* \tag{7}$$

If both these events occur, there is bi-directional feedback. When only one event occurs there is unidirectional feedback. In the presence of cointegration the Granger causality test is mispecified. The Granger regressions are therefore examined within the framework of an error correction model (ECM).

$$\Delta Y_t = g_0 + \sum_{k=1}^{n} q_k \Delta X_{t-1} + \sum_{j=1}^{n} v_j \Delta Y_{t-j} + f \hat{e}_{t-1} + w_t \tag{8}$$

$$\Delta X_t = g_0^* + \sum_{k=1}^{n} q_k^* \Delta Y_{t-1} + \sum_{j=1}^{n} v_j^* \Delta X_{t-j} + j^* \hat{e}_{t-1} + w_t^* \tag{9}$$

Where the error-correcting coefficients given by f and j. In both cases, the Granger causality test is based on the Wald test, which is given by:

$$W* = (\hat{b}_{UR} - \hat{b}_R) I(b_{UR}) \tag{10}$$

where $\hat{b}_{UR}, \hat{b}_R$ are the unrestricted and restricted parameters and *I( )* is the information matrix. The test statistics follows a chi-square distribution with degrees of freedom equal to the number of restrictions and corresponds to an F test (Pindyck and Rubinfield, 1998: 183).
To analyse the dynamics of the system, the VAR model in equation (1) is typically transformed into its moving average representation expressed as:

$$Y_t = \sum_{k=0}^{\infty} B_k Y_{t-k} + e_{t-k} \tag{11}$$

The moving average representation of equation (3) is an essential feature of Sims (1980) methodology in that it allows the tracing out of the time path of various shocks on the variables contained in the VAR system. Since there are six variables (markets) in the system for five sectors, there will be a total of 6×6 = 36 impulse response functions for each country sector. Rather than plot the impulse response functions to represent the behaviour of the (Y_{it}) series in response to the various shocks (e_{it}), the forecast error variance decomposition will show the proportion of the movements in a sequence (say market 1 in sector 1, Y_{1t}) due to its own shocks (e_{it}) versus shocks from other countries in sector 1 ($e_{2t} = e_{6t}$). Following Sheng and Tu (2000), if equation (11) is used to conditionally forecast Y_{t+p} the p-period forecast error is

$$Y_{t+p} - E_t Y_{t+p} = \sum_{k=0}^{p-1} B_1 e_{t+p-k} \tag{12}$$

Focusing solely on the Y_{1t}, sequence, we see that the variance of the p-step ahead forecast error variance of Y_{1t+p} is:

$$s_1(p)^2 = s_i^2 \sum_{k=0}^{p-1} a_{1,2}(k)^2 + \ldots + s_6^2 \sum_{k=1}^{p-1} a_{1,6}(k)^2 \tag{13}$$

where

$$B_1 = [a_{\partial pq}(k)]_{6x6} \text{ and } Var(e_{it}) = s_i^2 \tag{14}$$

and the ratio of:

$$W_1(i) = s_i^2 \sum_{k=1}^{p-1} a_{1,i}(k)^2 / s_1(p)^2 \tag{15}$$

represents the proportion of movements in country 1 sector 1, Y_{1t}, due to shocks from country i sector 1, e_{it}.

If $e_{2t} - e_{6t}$ shocks explain none of the forecast error variance of Y_{1t} at all forecast horizons, we can say that the Y_{1t}, sequence is ‘fully exogenous’. In such a circumstances, the Y_{1t} sequences would evolve independently of the $e_{2t} - e_{6t}$, and $Y_{2t} - Y_{6t}$, sequence. At the other extreme, $e_{2t} - e_{6t}$ shocks could explain all the forecast error variance in the Y_{1t} sequence at all forecast horizons, so that Y_{1t} sequences would be ‘fully endogenous’. The ratio $W_i(i)$, for $i = 1, 2, \ldots 6$ is the proportion of movements in country i and sector 1, Y, t, which can be explained by its own shock and can be used to represent the ‘degree of exogeneity’ of country i in sector 1 in response to the move towards the single currency. Orthogonalisation is achieved by using the Choleski decomposition, so that the resulting covariance matrix is diagonal (Friedman and Shachmurove, 1997). This basically amounts to assuming that the first country sector in the system has an immediate impact on all country sectors, excluding the first country sectors, and so on (Janakiramanan and Lamba, 1997).

4. Empirical results

Table 1 presents the ADF unit root tests (1) for the thirty European sector indices in price level and price-differenced forms. The five sectors examined are consumer discretionary, consumer staples, financial, industrials and materials and the six markets are Belgium, Finland, France, Germany, Ireland and Italy. In all instances, the null hypothesis of non-stationarity (unit root) and the alternative hypothesis of stationarity (no unit root) are tested for each series. Analysis of the price levels series indicates non-stationarity for all sectors except Ireland's materials and Germany's consumer staples sectors. However, all of the ADF tests statistics are significant in differenced form, indicating stationarity and the suggestion that each index series (other than materials in Ireland and consumer staples in Germany) is integrated of order 1 or I(1). The finding of non-stationarity in levels and stationarity in first differences provides comparable European evidence to Arshanapalli and Doukas (1993), Leachman and Francis (1995), Malliaris and Urrutia (1996) and Kanas (1998), amongst others.

TABLE 1. *Augmented Dickey-Fuller (ADF) unit root tests for sectors and markets*

Sector	Consumer discretionary		Consumer staples		Financial		Industrials		Materials	
Market	Price levels series	Price differenced series	Price levels series	Price differenced series	Price levels series	Price differenced series	Price levels series	Price differenced series	Price levels series	Price differenced series
Belgium	-1.7049	-14.1189***	-1.7887	-12.2214***	-2.3982	-8.1196***	-2.5747	-12.9032***	-1.8007	-15.9143***
Finland	-1.7126	-18.4591***	-1.8142	-7.6367***	-1.1666	-8.3183***	-2.7404	-12.3682***	-2.8101	-10.8592***
France	-1.2400	-11.6542***	-2.3550	-13.8588***	-2.2068	-10.1751***	-2.0765	-9.2184***	-2.7941	-18.5299***
Germany	-2.8587	-19.7418***	-3.8960**	-16.3846***	-1.3784	-11.8980***	-1.5084	-15.3271***	-2.5896	-8.8471***
Ireland	-1.9213	-6.3355***	-1.9082	-21.8947***	-2.2160	-7.3919***	-2.8270	-19.8894***	-3.5851**	-20.7757***
Italy	-1.7417	-8.5043***	-2.3088	-9.6758***	-1.6958	-9.5020***	-2.8281	-6.1976***	-2.5332	-7.1504***

Notes: Hypotheses H_0: unit root, H_1: no unit root (stationary); the lag orders in the ADF equations are determined by the significance of the coefficient for the lagged terms; for the price levels series, intercepts and tends are included; asterisks denote significance at the *** – .01, ** – .05 and * – .10 percent level.

The optimum number of lags to be used in the VAR model is determined by the likelihood ratio statistic (LR). The optimal number lags varies across sectors and markets. In the case of the consumer discretionary sector, Italy has the most consistent number of lags. The highest number of lags found is fourteen and the lowest number of lags is two. In consumer staples, the highest number of lags found is in Belgium and France with fourteen lags and the lowest in Ireland with two lags. In the financial sector the lags vary between two and eleven. Similar results are obtained for the industrials and materials sectors.

Johansen cointegration tests are used in order to obtain the cointegration rank. The trace test statistics are detailed in Table 2 for the various null and alternative hypotheses. The trace statistics are calculated to test the null hypothesis of r = 0 versus the alternative hypothesis of r > 0. All of the values are insignificant except for Belgium and Germany and Ireland and Italy in the consumer discretionary sector and France and Finland in the materials sector. Germany and Ireland are not included in the tests for the consumer staples and materials sector repectively because they are of order I(0). Critical values for these statistics are obtained from Osterwald-Lenum (1992).

The primary finding is that there are no stationary long-run relationships between most of the equity sectors and markets examined. This suggests that the level of long-run financial integration among these sectors is not as significant as that generally suggested by the analysis of the markets as a whole. However, this result must be taken in context. The failure to find a cointegrating vector across sectors demonstrates that across the sample the markets have not moved together in an equilibrium relationship. It does not mean, however, that there have not been sub-periods during which the indices may have moved together.

TABLE 2. *Johansen cointegration tests for sectors and markets*

Sector	Market	H_0	H_1	Finland	France	Germany	Ireland	Italy
Consumer discretionary	Belgium	r = 0	r > 0	8.273178	13.69693	21.97053**	13.04435	10.76099
		r = 1	r > 1	2.010459	5.120994	5.109868	4.458321	4.069333
	Finland	r = 0	r > 0		4.372450	9.671565	5.050475	4.958095
		r = 1	r > 1		0.556556	3.571958	1.735875	0.791446
	France	r = 0	r > 0			12.39693	15.83252	9.869117
		r = 1	r > 1			1.870480	2.392991	1.604206
	Germany	r = 0	r > 0				13.13996	10.13351
		r = 1	r > 1				2.327270	2.312369
	Ireland	r = 0	r > 0					21.24898**
		r = 1	r > 1					2.041571
Consumer staples	Belgium	r = 0	r > 0	10.72191	11.36311	–	9.320410	10.64579
		r = 1	r > 1	2.723603	3.387271	–	3.069101	3.043684
	Finland	r = 0	r > 0		12.39881	–	13.04544	10.82597
		r = 1	r > 1		4.064142	–	4.335302	3.438910
	France	r = 0	r > 0			–	12.17564	12.53846
		r = 1	r > 1				4.269271	5.972396
	Ireland	r = 0	r > 0					15.87052
		r = 1	r > 1					5.415332
Financial	Belgium	r = 0	r > 0	13.45844	19.05300	12.32394	11.83352	14.22280
		r = 1	r > 1	3.413072	8.893528	3.382483	2.260834	2.329205
	Finland	r = 0	r > 0		17.72493	16.18361	11.19024	8.596669
		r = 1	r > 1		3.191787	2.371000	3.704700	1.582966
	France	r = 0	r > 0			12.21252	15.29322	11.33966
		r = 1	r > 1			2.354923	5.459959	2.270855
	Germany	r = 0	r > 0				18.66444	6.207372
		r = 1	r > 1				3.419349	2.437057
	Ireland	r = 0	r > 0					7.497182
		r = 1	r > 1					0.824030
Industrials	Belgium	r = 0	r > 0	8.687164	15.45230	10.73795	12.47124	10.47270
		r = 1	r > 1	3.988647	4.865643	3.515425	3.660907	4.237924
	Finland	r = 0	r > 0		8.881757	7.369598	13.42255	13.60457
		r = 1	r > 1		1.663670	1.591914	3.549172	6.541126
	France	r = 0	r > 0			10.74793	10.60113	12.59149
		r = 1	r > 1			2.261066	3.139535	2.857464
	Germany	r = 0	r > 0				8.757621	10.84294
		r = 1	r > 1				3.499268	1.812467
	Ireland	r = 0	r > 0					18.25080
		r = 1	r > 1					6.603994
Materials	Belgium	r = 0	r > 0	10.19028	10.35376	8.698910	–	13.61195
		r = 1	r > 1	4.012988	3.343559	2.297952	–	6.015016
	Finland	r = 0	r > 0		20.95053**	11.69035	–	11.45251
		r = 1	r > 1		4.384575	2.629269	–	3.182942
	France	r = 0	r > 0			10.90281	–	9.238774
		r = 1	r > 1			2.587228	–	3.199775
	Germany	r = 0	r > 0				–	11.57378
		r = 1	r > 1				–	5.366456
	Ireland	r = 0	r > 0					–
		r = 1	r > 1					–

Notes: Critical values from Osterwald-Lenum (1992); the optimal lag order of each VAR model was selected using LR tests for the significance of the coefficient for maximum lags and Schwarz's Bayseian Information Criterion; in each cointegrating equation, the intercept (no trend) is included.

Since most of the sectors examined are found to have no cointegrating relationship, the Granger causality tests are performed on the basis of the VAR. However, for the sectors that are found to have cointegrating relationship (i.e. Belgium and Germany, and Ireland and Italy in consumer discretionary and Finland and France in materials) the Granger causality tests are performed on the basis of the ECM. Both equations are based on the Wald (?2) statistic and are calculated to test the null hypothesis that X (rows) does not Granger cause Y (columns), against the alternative X (rows) Granger cause Y (columns). The calculated *F*-statistics for all five equity sectors are detailed in Table 3.

TABLE 3. *Granger causality tests for sectors and markets*

Sector	Market	Belgium	Finland	France	Germany	Ireland	Italy	Caused
Consumer discretionary	Belgium	–	9.947386	15.82045*	21.40417**	13.37959	12.40146	2
	Finland	7.470424	–	7.405705	3.514645	3.670168	14.10504	0
	France	14.57310	5.684681	–	5.080172*	16.01034	32.64071***	2
	Germany	4.730586	0.367250	0.767956	–	1.918781	9.856323	0
	Ireland	14.02402	1.606765	53.60873***	6.138079**	–	29.28272***	3
	Italy	16.09731*	6.481310	22.22266**	2.312588	5.148395	–	2
	Causes	1	0	3	3	0	2	9
Consumer staples		Belgium	Finland	France	Germany	Ireland	Italy	Caused
	Belgium	–	6.936153	41.11039***	–	11.71340**	7.841099	2
	Finland	20.58252**	–	11.55499	–	6.981865	3.246213	1
	France	17.57382	3.687073	–	–	4.504909	12.38368	0
	Ireland	2.281426	12.61859	0.841542	–	–	19.91579**	1
	Italy	14.16982	8.977617	14.23886	–	8.093151	–	0
	Causes	1	0	1	–	1	1	4
Financial		Belgium	Finland	France	Germany	Ireland	Italy	Caused
	Belgium	–	2.483184	0.098480	0.199233	1.156508	15.59639*	1
	Finland	13.35777***	–	14.61003	10.11037***	16.13200*	17.52629*	4
	France	11.78122***	20.24094**	–	15.43622*	15.79103	13.20878	3
	Germany	3.289401	0.313808	9.306075	–	27.56694***	14.81296*	2
	Ireland	11.51178***	10.50364	33.52673***	12.06611**	–	31.68467***	4
	Italy	11.71530	20.87288	8.103912	11.19216	11.24690	–	0
	Causes	3	1	1	3	2	4	14
Industrials		Belgium	Finland	France	Germany	Ireland	Italy	Caused
	Belgium	–	9.325195	12.63954	2.889497*	4.376771	15.13862	1
	Finland	40.00277***	–	32.06673***	13.70015**	25.75385*	28.86745**	5
	France	10.99448	7.864002	–	17.16338	10.86681	11.98857	0
	Germany	0.875169	7.297514	11.84676	–	2.191170	4.957921	0
	Ireland	4.293499	6.544171	30.84508***	12.67013	–	26.06048**	2
	Italy	23.17909*	10.87835	19.36003	19.67398	12.35114	–	1
	Causes	2	0	2	2	1	2	9
Materials		Belgium	Finland	France	Germany	Ireland	Italy	Caused
	Belgium	–	7.680893	16.74280**	19.46322***	–	4.916071***	3
	Finland	5.533588	–	12.79091***	14.22842***	–	13.33034**	3
	France	15.77043**	3.721045	–	7.841105**	–	6.731678	2
	Germany	4.018748	6.443952**	8.611934**	–	–	0.472266	2
	Italy	1.743780	11.22126**	11.78825**	6.651829**	–	–	3
	Causes	1	2	4	4	–	2	13

Notes: Granger causality tests are conducted by adjusting the long-term cointegrating relationship by VAR and ECM; tests indicate Granger caused by row to column and Granger causes by column to row.

In the consumer discretionary sector, there are nine significant causal links at the 10 percent level or lower between the six markets. For example, Belgium affects Italy; France influences Belgium, Ireland and Italy; Germany influences Belgium, France and Ireland; and Italy influences France and Ireland. Further insights are gained by examining the total number of sectors caused indicating the effects of a particular market on all other markets. It is evident that the French and German consumer discretionary sectors are the most influential in the sample of EU Member States. In a similar cointegration approach, Friedman and Shachmurove (1997) also found that France affected the Belgian and German markets, while Meric and Meric (1997) established high pairwise correlations between France and Germany, Belgium and the Netherlands, though using a correlation approach. The least influential markets in terms of Granger-causality are Finland and Ireland. There is also an indication that there is feedback at play in several pairwise combinations: for example, Italy Granger-causes

France and France Granger-causes Italy. One possible reason for these results is that France and Germany are major producers of automobiles and electrical household appliances, which suggest their dominance over the European consumer discretionary sectors.

It is interesting to note that Finland does not Granger cause any other consumer discretionary sectors and no other consumer discretionary sectors Granger cause it. This suggests that Finland is the least integrated consumer discretionary sector within the sample examined. One implication of the results in Table 3 is that there may be no gains from pairwise portfolio diversification between those countries where a significant causal relationship exists. Also since we have a finding of causality these markets must be seen as violating weak-form efficiency since one of the markets can help forecast the other. In all other cases, the absence of Granger causality implies that there are sufficient short-run differences between the markets for non-European investors to gain by portfolio diversification.

The results for the remaining sectors differ markedly, suggesting that comovements between sectors, at least in the context of the sample considered, do vary across the EU Member States. For example, there are far fewer significant causal links between markets in the consumer staples sector (four or some twenty percent of possible relationships) than in say, the financial sector where nearly half of all relationships are significant and in the materials sector where more than half are significant. The results are not hard to justify. The pattern of relationships in the financial sectors is expected since the financial sectors of Europe are among the most integrated in the world and these countries have the same trading hours and are geographically close to one another. France has the highest correlation residuals across the EU financial sectors, thus the ordering will be achieved by examining the effects of a shock that originates in France and then moves on to Germany, Italy, Belgium, Ireland and Finland. Likewise, the larger material sectors of France and Germany dominate the sectors of other EU markets since France and Germany are large producers and exporters of chemicals and steels. However, there are a number of similarities between the results form the different sectors, most notably the dominant causal position of the French, German and Italian markets. In all

TABLE 4. *Generalised variance decomposition for sectors and markets*

Sector		Consumer discretionary							Consumer staples							Materials						
Market	HZ	France	Germany	Italy	Belgium	Ireland	Finland	Other	France	Germany	Italy	Belgium	Ireland	Finland	Other	France	Germany	Italy	Belgium	Ireland	Finland	Other
France	10	92.8626	1.0216	3.0119	0.1980	1.3308	1.5751	7.1374	97.2283	–	0.2708	0.5021	1.7176	0.2812	2.7717	95.1002	3.0190	0.4078	0.0413	–	1.4318	4.8999
	20	93.7945	0.9536	2.5720	0.1602	1.2079	1.3119	6.2055	96.3702	–	0.5652	0.3927	2.4313	0.2406	3.6298	92.4105	3.9630	0.2981	0.1090	–	3.2194	7.5895
Germany	10	28.5678	67.8642	2.6911	0.3884	0.2464	0.2420	32.1359	–	–	–	–	–	–	–	26.0624	73.4869	0.0206	0.0374	–	0.3927	26.5132
	20	31.5185	63.7962	1.7822	2.3218	0.1852	0.3962	36.2038	–	–	–	–	–	–	–	23.7401	75.8052	0.0374	0.0212	–	0.3962	24.1948
Italy	10	46.6314	0.0284	51.5990	0.7424	0.3843	0.6144	48.4010	27.0538	–	71.9894	0.4763	0.0354	0.4450	28.0106	17.8961	8.3284	73.6695	0.0830	–	0.0230	26.3305
	20	48.2969	0.3574	47.8299	0.9453	2.0428	0.5277	52.1701	35.4874	–	63.7029	0.2856	0.0360	0.4882	36.2971	18.9998	9.2885	71.2404	0.3486	–	0.1226	28.7596
Belgium	10	4.7900	10.8628	0.3873	82.4167	0.3360	1.2073	17.5833	18.4069	–	0.1855	76.1943	4.0386	1.1747	23.8057	11.0359	7.7383	0.8312	80.1895	–	0.2052	19.8105
	20	7.0260	13.4113	0.3356	77.9706	0.4430	0.8136	22.0294	15.7946	–	0.2162	76.1064	5.0903	2.7925	23.8936	10.8673	7.5311	0.5162	80.8072	–	0.2782	19.1928
Ireland	10	21.3290	2.6660	6.2150	0.3621	69.2845	0.1434	30.7155	1.1788	–	1.4558	1.1620	95.8715	0.3318	4.1285	–	–	–	–	–	–	–
	20	29.1823	3.7390	6.7120	0.4867	59.7218	0.1582	40.2782	1.8061	–	2.7735	1.2561	93.7344	0.4299	6.2656	–	–	–	–	–	–	–
Finland	10	7.7099	0.3393	1.0523	0.7485	0.3948	89.7551	10.2449	1.4584	–	1.7282	0.2835	0.8036	95.7262	4.2738	35.6672	3.2839	0.8947	0.4810	–	59.6732	40.3268
	20	10.2480	0.2402	2.8575	1.1423	0.2513	85.2607	14.7393	1.7401	–	3.4705	0.1826	0.9400	93.6668	6.3332	44.5424	2.5567	0.6571	0.8974	–	51.3464	48.6536
Average		35.1631	13.7733	10.5872	13.9903	11.3191	15.1671	26.4870	30.1534	–	14.5574	15.2208	19.8808	18.8087	13.9410	37.6322	19.5001	14.8573	16.3016	–	11.7089	24.6271

Sector		Financial							Industrials						
France	10	96.6871	1.3276	1.2793	0.1617	0.4401	0.1042	3.3130	97.0953	2.1529	0.3773	0.1182	0.0442	0.2121	2.9047
	20	93.4491	1.3100	2.5190	0.8340	1.6034	0.2844	6.5509	96.3619	2.7162	0.5490	0.0788	0.0269	0.2672	3.6381
Germany	10	28.6381	64.7605	4.4503	0.3656	1.2745	0.5111	35.2396	30.8727	68.3552	0.4702	0.1442	0.1050	0.0527	31.6448
	20	25.0349	62.4764	7.1045	0.4733	4.4770	0.4340	37.5236	29.0324	69.8157	0.9139	0.0820	0.0995	0.0565	30.1843
Italy	10	44.5801	2.3649	52.1832	0.1275	0.5078	0.2365	47.8168	17.8397	3.5151	77.7444	0.3083	0.0236	0.5689	22.2556
	20	41.8611	1.3765	52.9529	0.0854	2.6190	1.1051	47.0471	16.1793	7.3113	74.7187	1.0271	0.0504	0.7133	25.2813
Belgium	10	31.3387	3.5164	5.6453	57.3391	1.8644	0.2962	42.6609	7.6995	0.8367	0.9283	90.2323	0.0141	0.2892	9.7677
	20	32.3663	2.4220	10.4589	50.6556	3.5770	0.5203	49.3444	6.9450	1.6020	0.5477	90.4881	0.0086	0.4085	9.5119
Ireland	10	21.5588	1.6094	0.6806	0.5088	75.4892	0.1532	24.5108	8.8218	3.5298	1.1066	0.8765	85.6256	0.0397	14.3744
	20	25.5482	1.8761	4.2623	0.3792	67.8019	0.1323	32.1981	7.6093	5.1407	0.6776	0.5085	86.0313	0.0326	13.9687
Finland	10	3.9604	2.7704	2.9910	0.6304	2.0552	87.5926	12.4074	11.5393	2.4870	0.7577	1.8694	1.1753	82.1713	17.8287
	20	3.5747	2.6207	7.2153	1.1384	1.6178	83.8332	16.1668	12.3420	2.6994	0.7754	2.1822	1.2355	80.7654	19.2346
Average		37.3831	12.3692	12.6452	9.3916	13.6106	14.6003	29.5649	28.5282	14.1802	13.2972	15.6596	14.5367	13.7981	16.7162

Notes: Figures are percentages. The decomposition order is determined by the correlation of residuals. These are: France, Italy, Germany, Belgium, Ireland and Finland for consumer discretionary; France, Italy, Belgium, Ireland and Finland for consumer staples; France, Germany, Italy, Belgium, Ireland, and Finland for financial; France, Germany, Italy, Belgium, Ireland and Finland for industrials; France, Germany, Italy, Belgium and Finland for materials. The final column in each sector results (Other) is the percentage of forecast error variance of the market indicated in the first column (Market) explained by all other markets except the market's own innovations; the horizon periods (HZ) in the second column for each sector are in days.

five sectors these three markets account for more than fifty percent of the Granger-caused sectors all save one in the consumer discretionary sector. Of the significant cases, the results reveal that the generally larger sectors found in Germany, France and Italy lead the smaller sector in markets such as Finland and Ireland.

Table 4 presents the decomposition of the forecast error variance for 10 and 20-day ahead horizons for the sectors over the sample period. Each row indicates the percentage of forecast error variance explained by the column heading for the market indicated in the first column. For example, at the 10-day horizon, 93 percent of the variance in the French consumer discretionary sector is explained by its own innovations and 7 percent explained by innovations in other markets. However, in the Irish consumer discretionary sector for the same horizon period just 69 percent of variance is explained by variance in its own innovations, 21 percent by France, 3 percent by Germany and 6 percent by Italy. These and other results are interesting in that they illuminate aspects of market interaction not indicated by the Granger causality tests.

Overall, and on average, France and Germany account for relatively more of the forecast error variance across the five sectors examined. For example, France accounts for 30 percent of forecast error variance in the consumer staples sector and 37 percent in the financial sector while Germany account for 16 percent of forecast error variance in the industrials sector. However, the the average percentage of forecast error variance explained by markets other than the domestic market does vary, suggesting that some equity sectors are less integrated than others. For example, on average 'other' markets explain 26 percent, 28 percent and 25 percent in the consumer discretionary, financial and materials sectors respectively, but only 14 percent and 17 percent in the consumer staples and industrials sectors respectively. This says much about the differing efforts to integrate markets sectors in the EU.

5. Concluding remarks

This paper investigates long-term and short-term relationships among five sectors and six European equity markets during the period 1999 to 2002. All of these markets are Member States of the EU and participants in the third and final stage of EMU (the adoption of the euro). Cointegrating techniques are used to establish long-term relationships among these markets and Granger causality tests are used to measure causal relationships in the short-term within error correcting and vector autoregressive models. Generalised variance decompositions are also used to illuminate interrelationships obscured by causality tests.

In marked contrast to overwhelming evidence elsewhere that EU equity markets as a whole are highly integrated, few long-run equilibrium relationships are found between European sectors. While broad structural and institutional changes and convergence criteria aimed at achieving a high degree of sustainable economic convergence have ensured developments in the European monetary sector has gone far towards quickening the pace of overall financial integration, various impediments to the full integration of individual sectors has prevented this being reflected at the sector level. Nonetheless, the are a significant number of short-term causal linkages among the different sectors and markets, though these vary among the sectors with the consumer discretionary, financial and materials sectors being relatively more integrated than the consumer staples and industrials sectors.

The findings obtained in this paper have obvious implications for the purported benefits of international portfolio diversification among the many European equity sectors. In effect, the strong short-term causality and long-term linkages among the national markets would indicate that the returns from such a strategy have not diminished as markedly as one would expect at the market level. However, while the large sectors in France, Germany and Italy remain the most influential, the lower causal relationships that exist between these and the smaller sectors in Belgium, Ireland and Finland suggests that opportunities for diversification in these areas may still exist. This is further reinforced by the results of a decomposition of variance analysis that indicates that a distinguishing characteristic of most of the smaller markets is the relatively low level of variance explained by other markets.

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